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Reusing knowledge by Multi Agent System and Ontology

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Abstract— **the work presented in this paper is related to the knowledge management. We aim to reuse knowledge during the design processes, in order to help designers in all the phases of the products design.**

We propose a reuse knowledge approach based on the assistance of the professional actors with an automatic push (proposition) of knowledge and ease pull (search) of knowledge by helping individual searches. This approach is based upon a Knowledge Reuse System (KRS) which takes into account the roles of the professional actors and their collaborations throughout the product design process in order to bring an automatic help to the actors.

***Index Terms*— Knowledge Engineering, Multi-Agents System, Ontology, knowledge reuse**

I. INTRODUCTION

IN the face of greater product complexity, shorter product lifecycles and more exigency customers, every manufacturer is looking for something that can give him an edge, for instance, getting products to market faster.

During a design process, an amount of very important information and knowledge is exchanged among those involved in a project. As the speed of markets is rising and their dimensions tend towards globalisation, reaction time is shortening and competitive pressure is growing; information and knowledge losses may lead to a missed opportunity. This knowledge must be capitalized in order to be reused.

Reusing knowledge means reductions in the time, shorter delay to market (thus earlier time to revenue) and better knowledge exploitation.

To help users (employees, engineers, project manager…) performing their tasks, a Knowledge Reuse System (KRS from now on) can assist them in proposing relevant knowledge.

Our work fits into the knowledge management domain and particularly into its re-use and is focused on developing a system for reuse of knowledge and skills transfer in design engineering, which should exploit the capitalized knowledge [8]–[4] in the best way and propose it to the user to facilitate his tasks.

Monticolo [5] proposes a capitalization process based on an organizational approach called RIOCK (Role Interaction Organization Competence Knowledge), which enables the identification of Knowledge resulting from the interaction between the roles played by professional actors. This approach allows the knowledge management during mechanical design projects and consists in associating a Knowledge Engineering package to a PLM (Product Lifecycle Management) system in order to reuse technical knowledge.

This KRS offers the relevant knowledge to the right person. This help can be automatic with push functionality or directed by the user with pull functionality [7].

We aim by this work to conceive a KRS which takes into account the roles of the professional actors and their collaborations throughout the product design process while bringing an automatic help to the actors to facilitate their tasks and a personalized search for the knowledge.

This paper presents an ongoing effort in developing a multi agent System (MAS) for reusing Knowledge. It is organized as follows: In Section 2, we introduce the background of this work. We present our reusing knowledge process in Section 3. In Section 4 we give an overview of related work and we conclude by stating the main research ideas and future research directions.

II. BACKGROUND

There exists two kinds of knowledge; tacit and explicit knowledge [22].

Nonaka [18] drawing on [23] mentioned that tacit knowledge is mental (mental schemata, beliefs, images, personal points of view and perspectives, concrete know how e.g. reflexes, personal experience, etc). Tacit knowledge is personal, context-specific, subjective and based on experience. Therefore, tacit knowledge is hard to formalise and communicate. It also includes cognitive skills such as intuition as well as technical skills such as craft and know-how. Explicit knowledge, on the other hand, is formalised, coded in a natural language (French, English, etc) or artificial (UML, mathematics, etc) and can be transmitted. It is objective and rational knowledge that can be expressed in words, sentences, numbers or formulas. As explicit knowledge is visible, it was the first to be managed and our work is based on this type of knowledge. Basing on a rational design of the knowledge, KM aims to re-use this knowledge which is supposed to be

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beforehand identified, codified and integrated into the production process.

Our knowledge cartography is inspired from Monticolo's research work [5]. It is based on an organizational approach for knowledge management during mechanical design projects. The social and cooperative aspects of the design process are taken into account. In fact, we adopt the hypothesis that knowledge is exchanged when professional actors work together. To carry out their collaborative tasks, professional actors have to create, use and share knowledge. They reach a common objective: the development of a new mechanical system. Four aspects were developed in this work:

- The elaboration of an organizational model of the design process where are represented the roles of the professional actors, their skills, their interactions as well as the knowledge they use and share throughout the design activities. This model is a guide for the knowledge capitalization during the mechanical design projects;
- The definition of a project memory model, MemoDesign, supplying a frame for the indexation of knowledge to be archived during design projects;
- The build of an ontology called OntoDesign allowing the knowledge handle of the domain;
- The conception and the setting-up of a multi-agents system called KATRAS taking into account the social and cooperative aspects of the design process and in charge of the construction of project memories of the mechanical design projects.

KATRAS handle knowledge which should be structured and organized in ontology. Ontology [17] refers to an *engineering artifact*, constituted by a specific *vocabulary* used to describe a certain reality, plus a set of explicit assumptions regarding the *intended meaning* of the vocabulary words. It involved how to constrain the use of the data [11] and it is used widely in the semantic web approach, which requires a significant degree of structure.

Based on MemoDesign we built our domain ontology shown in figure 2 which enriches OntoDesign and proposes a vocabulary and a semantic defining the concepts corresponding to the capitalized knowledge and their attributes.

Our KRS is based on the knowledge identification from an organisational approach to model the professional processes implemented in projects. Our modelling is built with the concepts of Roles, Interactions, Organization Competence and Knowledge [10]–[5].

Concepts of the meta-model RIO agree perfectly to model the design process: we represent a design activity by an organization. In this organization we represent the roles of the professional actors in interaction. The interaction symbolizes the collaboration between the actors which expresses itself by the realization of a deliverable (objective of the organisation/activity) and the sharing of the knowledge between the roles. So, by means of RIO, we represent a phase of the process by divisible organization in activities which are themselves represented by organizations.

The meta-model RIO does not allow explicit representation of the skills and the knowledge used by the role when they interact with the other roles in the same organization. Monticolo [5] allocates to these roles the competences which they use to achieve the activities. The competence is the capacity for an individual to implement its knowledge and to develop its know-how [14]. Competences are also developed during the achievement of professional activities, in which the exchange of knowledge takes place. Each competence is aggregated with a set of knowledge.

Figure 2 shows an example of RIOCK model. In the activity (i.e. organization) 'to analyse the customer requirements' we observe two roles. The role 'Technical assistant' uses one of its competences; we read it like *the capability to* 'Formalize the customer requirements'. This competence requires one element of Knowledge which is used to satisfy the organization. In the RIOCK diagram the type of knowledge is read like *Knowledge on*, for example the role 'Technical assistant' possesses the Knowledge on 'Customer requirements'.

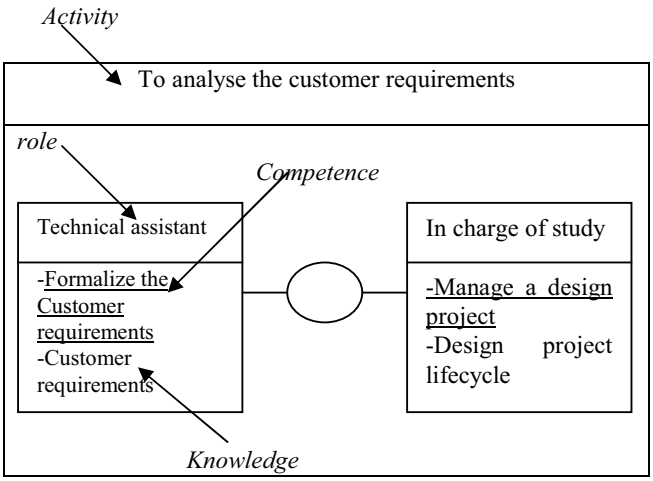

Fig 1.RIOCK model for the activity "to analyse the customer requirements"

III. REUSING KNOWLEDGE PROCESS

A. Building the ontology

The first step of the knowledge reuse process aims to define the relations between the concepts, attributes and relationships between them. This leads to the building of the Ontology by enriching OntoDesign which allows handling the domain knowledge.

OntoDesign should be enriched to add other knowledge related to the product like "technical parameters" of its elements or technical functions of some concepts. This enrichment allows the KRS to satisfy more the user's needs by offering knowledge which can help the user in his tasks.

We begin to enrich OntoDesign in adding other concepts, attributes and relations which respect the hierarchical aspect of this model e.g. *Technical parameters* is a subclass of *Element*.

The figure 2 presents a graphical view of the ontology with the relations, attributes and concepts associated of projects which aim to get products.

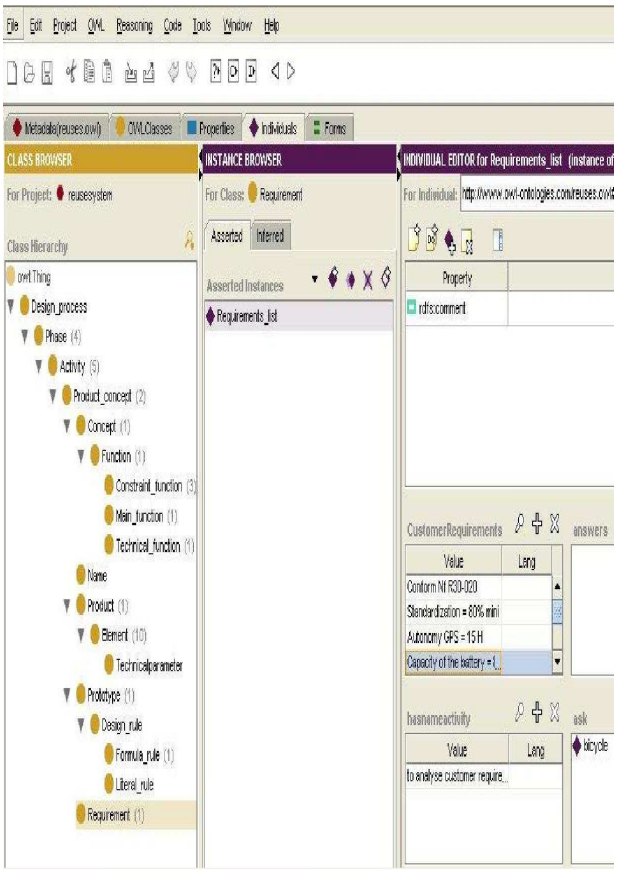

Fig 2.Building the ontology with Protégé 3.4 beta

To concretize our approach we adopted a concrete example of design project which aims to produce “a bicycle”.

Figure 2 shows that the product concept “bicycle” answers the requirements listed in the table “CustomerRequirements”. For instance, requirements of the product concept “bicycle” are: Conform NF R30-020, Standardization = 80% mini…

Building the ontology by specifying the project concepts, their relationships and attributes and identifying knowledge inside professional processes constitute the base of the knowledge reuse process which is explained in the following diagram. We use multi-agent systems to support use, monitoring and maintenance of the ontology.

B. Multi agent system description

KATRAS [5] build project memories during the product development lifecycle by capturing and capitalizing knowledge resulting from the design collaborative activities. Once this knowledge is capitalized, our system will be in charge of allowing its reuse during the design process.

Our KRS offers two kinds of help: push and pull functionalities [7] which are explained in paragraphs D and E.

The user may use such a system at several stages of their integration process: when they just arrived in the organisation, it is interesting to push interesting information to them; as they grow confident and learn to use the system, they will use pull functionality to extract specific information from the memory.

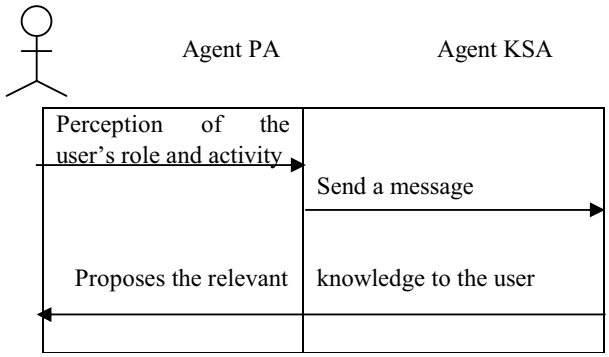

Fig 3.Sequence Diagram for Knowledge reuse process

In this process, there exists two types of agents:

- Professional Agents (PA) are created as soon as professional actors are assigned in a project. There is one agent for each professional actor per project. PA agents detect information about the user and his activity.
- Knowledge searcher agent (KSA) has as role to search relevant knowledge for the user identified by PA.

This process is available for both push and pull functionalities. The difference between them is that push functionality take action automatically after detecting the user role and activity but pull functionality answers for some detailed and specific information e.g. the technical parameter of one element of the product. We detail the knowledge reuse process in the following subsections.

C. Perception of user’s roles and activities

The users communicate with their agents via PLM interface. Every user is followed by PA that detects his role and activities. The user role detection is made throw his identification when he opens his session. According to this information the agent looks in his memory for the organizational model which describes the same activity for the same role and gets the knowledge associated following RIOCK model. Once the knowledge is found it sends a message to KSA to supply the instances of this knowledge.

The figure 4 shows the xml file which represents organisational model with activities, roles, competences and knowledge.

For instance, for push functionality, when the PA detects the activity “to analyse the customer requirements” for the role “Technical assistant” it will get the knowledge associates

following RIOCK model which is “Customer requirements”. It detects also in the product’s name field the term ‘bicycle’ which allows the search for the knowledge associated to this product.

After detecting all those information, PA sends a message to agent in charge of searching knowledge (KSA) containing the product’s name and the associated knowledge.

For pull functionality, the PA detects the activity name, the user role and the term in the searching field. The KSA search the correspondent knowledge according to the information provided by the PA.

Fig 4.XML file for RIOCK models

D. PUSH: Proposes the relevant knowledge to the user

Agents are implemented in the Madkit Platform [9] and used the java jena API to handle the OWL ontology.

When the agent in charge of searching knowledge (KSA) receives the message from the PA, it searches it in the ontology. For instance, it has to search attributes of the concept “requirements” which answers to product ‘bicycle’. It queries the owl ontology with SPARQL Query Language. SPARQL is a W3C Candidate Recommendation towards a standard query language for the Semantic Web. Its focus is on querying RDF graphs at the triple level. SPARQL can be used to query an RDF Schema or OWL model to filter out individuals with specific characteristics. An example of a Sparql query is presented below. It searches the list of names of the attribute CustomerRequirements for product_concept ‘bicycle’.

```
PREFIX reuses: <http://www.owl
ontologies.com/reuses.ow#l>
SELECT ?CustomerRequirements
WHERE {
?Product_concept  reuses :CustomerRequirements
?CustomerRequirements
{
{
?Product_concept  reuses :hasnameproductconcept
‘bicycle’
```

As a result of the Sparql query the user receives a help window which provides him with knowledge in need. Figure 5 shows an example of the help window.

```
{CustomerRequirements: Conform NF R30-020}
{CustomerRequirements: Standardization = 80% mini}
{CustomerRequirements: Autonomy GPS = 15 H}
{CustomerRequirements: Hygrometry = 0-100%}
{CustomerRequirements: Capacity of the battery = 8A/h}
{CustomerRequirements: Maximum mass of the VAE =
30 Kg}
{CustomerRequirements: Mass of the VAE + user’s
mass= 30 Kg}
…
```

Fig 5. The help window proposed to the user

By the way, the help concerns also the list of the product’s elements, the list of the technical parameters for each element, functions of each concept…

The user can take into account this help and can also ignore it.

E. PULL: PERSONALIZED SEARCH FOR THE KNOWLEDGE

We adopted the same approach using the organizational model RIOCK so that the user can make the personalized search of knowledge.

PA detects the user role, his activity and the term in the searching field. When it searches for knowledge, the result of the application will depend on his role in the product design project.

To concretize this idea, we have taken as an example the organization / activity " To write the breviary of knowledge” that involves several roles shown in figure 6.

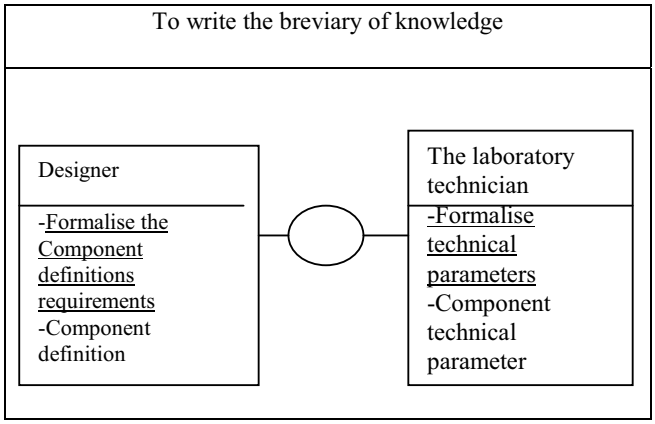

Fig 6.RIOCK model for the activity "To write the breviary of knowledge"

Among these roles: The designer, who has as knowledge the definitions of each component of the product, the laboratory technician who has as knowledge the technical parameters of each component and other roles.

We have followed the design project which aims to product a car which will serve as a basis for seeking knowledge.

If the designer enters the term of "Mechanical frame" in the search field, it will have as a response to this application the definition of the mechanical frame. If the laboratory technician enters the same term he will have the technical parameters of the frame.

After the identification of the user role, activity and the term in the searching field by the PA, the KSA formalize this query

```
PREFIX reuses: <http://www.owl
ontologies.com/reuses.ow#l>
SELECT ?ComponenetDefinition
WHERE {
?Element  reuses :ComponentDefinition
?ComponentDefinition
{
{
?Element  reuses :hasnameelement 'Mechanical frame'

.....
```

The result of this Sparql query is as follow:

{ComponentDefinition: The Mechanical frame is a structure generally made up of beams and bars connected by welding or by elements of connection}

The personalized search for the knowledge limits the search space and proposes to the user only the knowledge that he needs.

IV. RELATED WORK

Knowledge Engineering aims to collect, analyze, structure, represent and reuse Knowledge.

Knowledge environments can be seen as distributed systems where actors with different specialities share their know-how in order to achieve their professional activities [5]. In such environments the choice of multi agents system is motivated by the following functionalities:

- To manage the heterogeneous and distributed Information,
- To solve complex problems in split them,
- To provide an assistance to professional actors in reusing Knowledge,

Many works were done on this domain;

Gandon [8] adopts an innovative approach for the management of an organizational memory [16] combining the ontology engineering, semantic Web and MAS in an integrated solution. He tackled the problem of knowledge reuse basing on the user profile which is a description of their interests, activity, ect. But without taking into account the role of the user in the design process. Tacla [27] developed a model for the cooperative construction of reports of project. In this model, after an initial modelling of the domain, the acquisition of the knowledge is made in an ascending and integrated way, from the daily activities of the individuals. Tacla research works supply a runway for the re-use of the knowledge by explaining how to capitalise it but they do not handle the automatic assistance of the users to help them by reusing knowledge.

Some works focused on the user task to put in context such assistance [25]–[13] while others tried to capture general web navigation episodes on static signatures [6]–[15] or, like [1], used past procedure cases to help their use in specific applications.

Champin [21] suggests exploiting tracks of use of the tacit knowledge of the designer by means of the mechanisms of reasoning from case.

These last works rely on the Case-Based Reasoning paradigm [29]–[20]. These researches aim at tracking and reusing experience but for our case we want to reuse knowledge contained in the ontology via concepts, attributes and relations.

Other research works focused on information research by the source's description [3]–[19] or by selection of minimum number of sources for a given request [28]. Those works don't take into account the user profile in the search process and the context of the design process.

Several approaches were developed to define the user profile, we can quote: the adaptive approaches [26], the semantic approaches [2]–[24]; multidimensional approach [12].

All these works try to adapt to the user's preferences and interests in searching information.

In our research we try to search knowledge which is the interpretation of information by a human in a given context according to the user's role in the product design project which consists the main criterion of the user profile in searching knowledge.

V. CONCLUSIONS

In this article, we propose a knowledge reuse approach based on the assistance of the professional actors with an automatic knowledge push and which eases it pull by helping individual searches. This approach is based upon a knowledge reuse system (KRS) which takes into account the roles of the professional actors and their collaborations throughout the product design process while bringing an automatic help to the actors.

The first step of this approach is based on the use of the RIOCK formalism by MAS to identify Knowledge. For push functionality, the PA detects the user role, the name of the activity and the product name, for pull functionality, it detects also the term in the searching field, so it can identify the correspond knowledge Once knowledge is identified, the MAS takes in charge the search of its instances by querying the OWL ontology and proposes it to the user.

This work allows exploiting capitalized knowledge and represents two forms to reuse knowledge: push and pull functionalities but it does not allow the user to negotiate with the system to have more relevant knowledge. Our future work will focus on other forms of knowledge reuse like a negotiator system that offers more specific knowledge.

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